Environmental Conditions

General

Environmental conditions minimally consist of thermal, mechanical and chemical quantities. These can influence performance, safety and EMC behaviour as well as the time to failure of a power supply.

Immunity to Environmental Conditions is specified for all Power-One power supplies in the corresponding data sheet.

Basic Environmental Testing Standards

Basic Environmental Testing Standards specify test procedures and severities for application to components or equipment designed to withstand a corresponding environmental condition. The specified test conditions related to the intended environment are usually chosen to be more severe than those expected in normal service in order to reduce testing time. The standards serve as reference documents for the product committees of the standardization bodies and give guidance in order to assign severities to the environment in which the equipment is intended to be used.

Basic Environmental Testing Standards are general standards which are not dedicated to specific product families or products and should not prescribe severity levels for product families or products. These are covered by the *Product Family* or *Product Standards*.

Environmental type testing is specified in the table *Mechanical stress* of the power supply data sheets. Testing was performed with representative units of the corresponding power supply family for the specified duration. During and/or after the test, no damage or degradation of performance and safety could be observed. These specifications should be compared with the test requirements (not the continuous service requirements) of the end product in which the power supply shall be implemented. Environmental tests are specified in most *Product Family* or *Product Standards*.

The following table lists some basic environmental testing standards, with severities typical for Power-One power supplies for *Rugged Environment*.

Test method		Standard	Test conditions		Status
Ca	Damp heat, steady state	IEC/DIN IEC 60068-2-3 MIL-STD-810 D, section 507.2	Temperature: Relative humidity: Duration:	$40^{\pm 2}$ °C $93^{+2/-3}$% 56 days	Unit not operating
Ea	Shock (half-sinusoidal)	IEC/EN/DIN EN 60068-2-27 MIL-STD-810 D, section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	100 g_n = 981 m/s^2 6 ms 18 (3 each direction)	Unit operating
Eb	Bump (half-sinusoidal)	IEC/EN/DIN EN 60068-2-29 MIL-STD-810 D, section 516.3	Acceleration amplitude: Bump duration: Number of bumps:	40 g_n = 392 m/s^2 6 ms 6000 (1000 each direction)	Unit operating
Fc	Vibration (sinusoidal)	IEC/EN/DIN EN 60068-2-6 MIL-STD-810 D, section 514.3	Acceleration amplitude: Frequency range (1 Oct/min): Test duration:	0.35 mm (10...60 Hz) 5 g_n = 49 m/s^2 (60...2000 Hz) 10...2000 Hz 7.5 h (2.5 h each axis)	Unit operating
Fda	Random vibration wide band – Reproducibility high	IEC 60068-2-35 DIN 40046, part 23	Acceleration spectral density: Frequency band: Total acceleration magnitude: Test duration:	0.05 g_n^2/Hz 20...500 Hz 4.9 $g_{n\ rms}$ 3 h (1 h each axis)	Unit operating
Kb	Salt mist, cyclic (sodium chloride NaCl solution)	IEC/EN/DIN IEC 60068-2-52	Concentration: Duration: Storage: Storage duration: Number of cycles:	5% (30°C) 2 h per cycle 40°C, 93% relative humidity 22 h per cycle 3	Unit not operating

Standard Conditions for Power-One Power Supplies

Power-One's standard specifications of performance, safety, EMC, operating ambient temperature T_A, operating case temperature T_C and storage temperature T_S relate to normal, quasi-stationary air (free convection) with a pressure of 800...1200 hPa (800...1200 mbar) and to a relative humidity of up to 90%. 800 hPa is equal to a height of 1850 m (6000 ft) above sea level.

Storage, transportation and operation under different conditions may be possible, but their influence on the power supplies must be considered carefully. The following table shows some considerations to be made.

Considerations	Deviation from standard conditions				
	Lower pressure	Higher pressure	Other gases	Fluids	Solid materials
Thermal	Reduced heat transportation capability	Improved heat transportation capability	Heat transportation capability	–	Heat transportation capability
Electrical	Reduced electric strength of the relevant clearances	Improved electric strength of the relevant clearances	Electric strength of the resulting relevant clearances, creepage distances and distances through media		
Chemical	–	–	Possible reactions with materials of the power supply		
Mechanical	–	Possible damage of material	–	–	Possible damage of materials due to different coefficients of expansion of surrounding material (e.g. potting) and power supply

For more information relating to concrete projects please consult Power-One.

Product Reliability and MTBF

Definitions

a) Failure
Inability of a specific unit to conform to the demanded requirement.

b) Error
A defect with little or no influence to the unit in question.

c) Imperfection
A non-coincidence caused by imperfection during development, design or production.

d) Defect
A defect is a failure with limited influence to the effect of fulfilment of the required function.

e) Random Failure
A failure with an inherent weakness of a specific unit. Assumption: The sample is not overstressed. Random failures occur randomly and can only be predicted by probability calculation.
In contrast to random failure is a failure caused by a fault or wear-out as a consequence of ageing, wear and tear.

f) Failure Rate for Electronic Components (simplified model according MIL-HDBK-217).
After passing a period of infant failures one assumes a constant failure rate λ.

$$\lambda = \frac{\text{number of failures}}{\text{total device hours}} \text{ [1/h]}$$

Remark:
Mean Time Between Failure MTBF = $1/\lambda$ (hours) with repairable units and constant λ. Therefore it is meaningful to speak about MTBF if the failure rate is constant and the unit can be repaired.
MTBF = horizontal part of the bathtub curve.
Other definitions:
MTTR = Mean Time To Repair
MTTF = Mean Time To Failure

g) Screening
A sequence of stresses applied to a unit to force infant failures. This pertains to the falling part of the bathtub curve.

h) Burn-in
An operation of a unit during a defined period of time with increased temperature to stabilise some features as well as to force infant failures.

i) Derating
An intentional under-loading of a unit or a component in use to reduce probability of failures.

j) Life time
The total working time of a non repairable unit. A more common expression than life time is mean time to failure (MTTF).

k) Useful life
We understand useful life as the total life time for a repairable unit. This pertains to the rising part of the bathtub curve.

l) Bathtub curve
This describes an empiric model showing the failure behaviour of repairable units (one or several) or a total of identical non-repairable units.

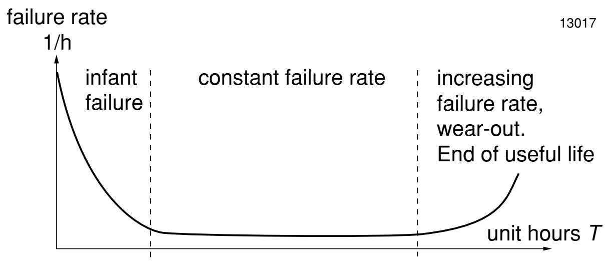


Fig. 1
Life cycle failure rates

m) Reliability

The reliability of a specific unit is the probability that a specified function under given conditions during a predicted unit operation time T is feasible.

With constant failure rate (for electronic components and systems) the reliability R for time T is calculated

$R = e^{-\lambda T}$, (Exponential law, λ = constant)

$= e^{-T/MTBF}$, (T = working hours)

The reliability decreases exponentially as a function of time.

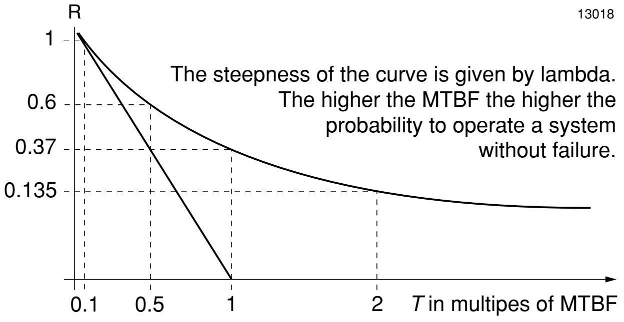


Fig. 2
Reliability as a function of time

Some Elements of the Reliability Theory

As long as we are working with electronic systems (Power-One power supplies) we can count on a constant failure rate (after burn-in).

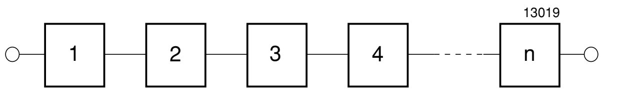
The military handbook MIL-HDBK-217, which is a US-military collection of failure rates, considers a constant failure rate λ for the listed components. (It is possible to do the calculations with non-constant failure rates. A complicate task, time consuming, for which general rules can no longer be used.)

Dimensions of the failure rate λ:
1 failure/10^6 hours = 10^{-6} h^{-1}
1 failure in time = 1 fit = 10^{-9} h^{-1}

For components (not repairable):
$1/\lambda$ = MTTF (Mean Time to Failure) = life time (statistical experience).

For systems:
λ_{total} = sum of λ of all components.
This means: Series model (non redundant)
$\lambda_{total} = \lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \dots \lambda_n$

MTBF = $1/\lambda_{total}$ (experienced failure-free working time).



MTBF is a function of load conditions, count of switch-on-conditions, complexity and so on.

Environment per MIL-HDBK-217

G_B Ground, Benign
Non mobile, temperature and humidity controlled environments; includes laboratory instruments and test equipment, medical electronic equipment, business and scientific computer complexes.

G_F Ground, Fixed
Permanent installation in moderately controlled environments; including air traffic control radar and communication facilities in unheated buildings.

G_M Ground, Mobile
Equipment installed on wheeled or tracked vehicles and equipment manually transported; includes mobile communication equipment and tactical fire direction systems.

N_S Naval, Sheltered
Includes sheltered or below deck conditions on surface ships and equipment installed in submarines.

MTBF Figures for Power-One Power Supplies

MTBF figures for Power-One power supplies per MIL-HDBK-217 are given in the corresponding data sheets under *Immunity to Environmental Conditions*.

Please note that the figures have been calculated based on operation at nominal conditions ($U_{i\ nom}$ and $I_{o\ nom}$) and the specified case temperature T_C of the power supply which is approximately equal to the ambient temperature of the built-in electrical components. Additional temperature rises of heat dissipating components have been considered.

Neglecting the temperature rise due to power dissipation and using the ambient temperature T_A of the power supply as component temperature would lead to incorrect, higher MTBF results.

Some of the reasons for the high MTBF figures of Power-One power supplies:

- Continuous selection and evaluation of top quality components
- Designs optimized for low component stress
- Ambient to case temperature difference below approx. 24 K
- Low power loss due to high efficiency
- Avoidance of hot spots

Device Hours

The expected reliability of Power-One products is specified in terms of Device Hours. These values are based on data retrieved from the repair service and from the Power-One quality reporting system.

Device Hours (*DH*) for the year *n* are calculated as follows:

$$DH_n = \frac{WH}{FY_n}$$

where:

- WH = Working Hours, the cumulated working hours over the previous three years of all products of the specified converter family sold over this period. For each year 4300 hours of operation are assumed.
  $WH = (Q_{n-2}) \cdot 3 \cdot 4300 + (Q_{n-1}) \cdot 2 \cdot 4300 + Q_n \cdot 4300$
- $Q_n \ldots Q_{n-2}$ = Quantities sold in each year *n*...*n*-2.
- FY_n = Failures recorded in year *n*.

Failures are all recorded defects which are due to component failures and manufacturing imperfections. Power-One processes all failed units in one repair center and maintains a database of all reported failures.

In the data book the latest available data is reported. More detailed data is available upon request.